Zo Vic
- Summary
- It should include a short summary and then explore the area of the paper. To help you prepare going forward, here are a few questions you can consider including.
- What are major companies that supply products (e.g. software, hardware, etc.) or services (e.g. cloud services like Amazon EC2, training, etc.) relevant to this course topic?   Are these well-established companies or startups?   Who are the primary customers: individual users, small businesses, large enterprises, etc.? Briefly describe these goods and services.

Isaac
- How is the marketplace segmented?   What is the basis of the segmentation? In each segment, which are the major and minor players?
- What is the business model?   How do the companies make money?   What are the major costs involved?   Do these business models trigger any significant policy issues (e.g. privacy)?

- What are the major standards in this arena? Are these official standards or informal standards that have evolved?

Kunal
- Are there capabilities discussed in the research papers for this topic that are missing from the marketplace?   What might be the reasons for this gap?
- Does commercial practice reveal important unaddressed research topics?   Why have these topics not been investigated?

- Are there significant unmet needs in this space?   Why have these needs remained unmet?

Summary - The Problem

Core Problem:
Current crowd monitoring systems in large public venues (stadiums, arenas) fail to balance **accuracy, cost, and privacy**.

Summary - Why is it important

Safety: Prevent disasters like stampedes and riots (e.g., Kanjuruhan Stadium, Seoul Halloween Stampede).

Security: Detect risky crowd dynamics or unusual movement.

Experience: Understand audience engagement and reactions.

Operations: Optimize gate usage, staffing, and facility management.

Summary - Existing Solutions

Method	Pros	Cons
Manual Observation	Direct, human judgment	Costly,delayed,inconsistent
Video / Audio Systems	High accuracy	Privacy concerns, data overload
WiFi / RF Tracking	Wide coverage	Noisy, inconsistent signals
Wearables / Apps	Individual accuracy	Poor scalability
Questionnaires	Social/behavioral insights	Not real-time

Summary - GameVibes Approach

Core Idea:

Use **floor-mounted vibration sensors** + **contextual modeling** to infer crowd reactions and traffic.

Key Components:

1. **Game Associations (Temporal Context):**
   - Link reactions (clapping, stomping) to **game progress**.
2. **Facility Associations (Spatial Context):**
   - Link traffic flow to **layout features** (doors, food stands).
3. **Neural Network Encoders:**
   - Model the features and relationships within the data to estimate crowd behaviors.

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Summary - Why It's Better

1. **Privacy-Friendly:** No images or sound collected.
2. **Low-Cost & Scalable:** Uses inexpensive vibration sensors.
3. **Context-Aware:** Models *why* vibrations happen, not just *when*.
4. **Robust:** Works across different venues and sensor locations.

Results (Stanford Maples Pavilion):

- 0.9 **F1 Score** (crowd reaction detection)
- 9.3 **Mean Absolute Error** (traffic estimation)
- **~10–12%** increased accuracy improvement vs. baselines.

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Industry Ecosystem

Established Companies:

- **Bosch:** Manufactures IoT and vibration sensors; smart infrastructure analytics.
- **Honeywell:** Building automation, safety systems, and industrial monitoring.
- **Siemens Smart Infrastructure:** Occupancy, motion, and structural sensing for large venues.

Startups:

- **Density.io:** Radar-based, anonymous people-counting sensors for buildings and arenas.

Potential Primary Customers

Large Enterprises:

Stadiums, airports, factories: Operate large facilities needing real-time crowd and safety management systems.

Government / Smart City Planners:
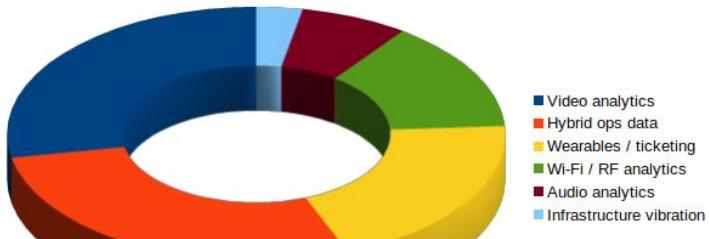
Manage public safety, traffic flow, and smart infrastructure using integrated sensing and analytics.

Event Organizers:
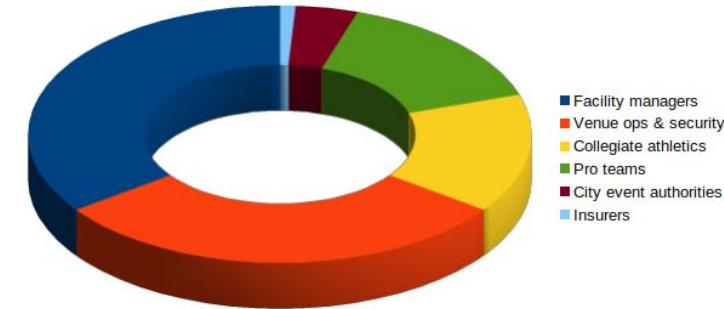
Sports leagues, concerts, and festivals: Use crowd analytics to ensure safety and enhance audience experience.

Market Segmentation: "How is the marketplace segmented?"
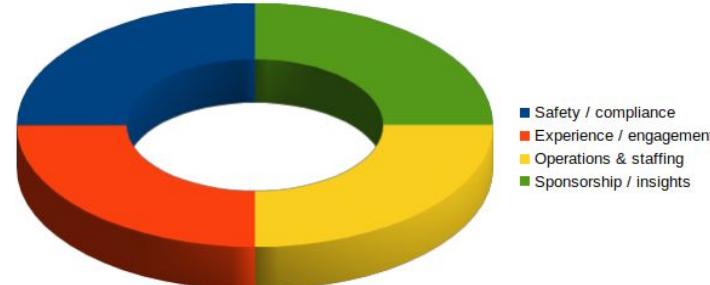
By sensing modality & data source

- Video analytics
- Hybrid ops data
- Wearables / ticketing
- Wi-Fi / RF analytics
- Audio analytics
- Infrastructure vibration

By buyer

- Facility managers
- Venue ops & security
- Collegiate athletics
- Pro teams
- City event authorities
- Insurers

By value proposition

- Safety / compliance
- Experience / engagement
- Operations & staffing
- Sponsorship / insights

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Basis of Segmentation: "What's the basis?"

Privacy sensitivity

Cost & deployability

Context integration

Coverage & granularity

Robustness in noise / crowds

Players by Segment: "Major players?"
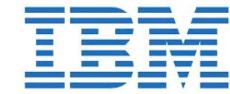
Video analytics

Hybrid ops data

Wearables / ticketing

Wi-Fi / RF analytics

Audio analytics

Infrastructure vibration

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Business Models: "How do companies make money? Major costs?"

Revenue models

- Hardware + install
- Software licensing / SaaS
- Data services
- Systems integration / support

Cost drivers

- Hardware CapEx
- Ops OpEx
- Labeling & ground truth collection
- Model development & tuning

# Policy & Risk: "Do models trigger policy issues (e.g., privacy)?"
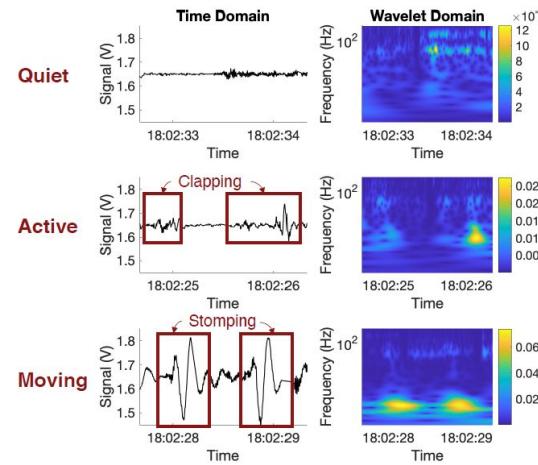
Risk Area	Severity	What It Means	Mitigation
Privacy & Transparency	🟢 Low	No faces/voices captured, but venue must disclose monitoring.	Post clear signage and publish data-use policy.
Data Governance	🟡 Medium	Data could be repurposed if not controlled.	Use retention limits and defined access roles.
Safety & Liability	🔴 High	Alerts imply responsibility to respond.	Define escalation procedures and alert thresholds.
Bias & Fairness	🟡 Medium	Models must work across crowd types & layouts.	Validate performance across varied events.
Cybersecurity	🟡 Medium	Mesh networks must be protected.	Encrypt traffic and segment networks.

Privacy vs. Life??

CCTV or Person Monitoring

Floor vibration Monitoring

The Market Reality

Current Products

- Stadiums deploy AI cameras (e.g., NEC, SAFR) despite privacy pushback
  - Sporting Kansas City facilities
  - UEFA Super Cup Final 2020

- Surveillance acceptance rises *only after* tragedies (e.g., Seoul 2022, Kanjuruhan 2022)

**These commercial tools save lives but sacrifice privacy, What if we didn't have to choose??

Why Market Adoption Lags Behind Research

Barrier	Explanation
⚙️ Structural variability	Stadium floors differ; hard to generalize models
💾 Limited datasets	Few long-term, multi-venue vibration datasets
💰 ROI uncertainty	Hard to prove cost-benefit to venue operators
🧯 Liability & inertia	Safety tech adoption moves slowly due to regulation

Video Surveillance: Legal but Limited - The Smart Monitoring Gap

- Regulatory Restrictions on AI Features
    - Facial recognition: Banned (EU, 20+ US cities) or requires consent (Illinois, California)
    - Emotion detection: Banned in EU for most uses
- Privacy Perception & Reputational Risk
    - Madison Square Garden facial recognition scandal (2022)
    - Taylor Swift concert facial recognition outrage (2018)

AMERICA RECKONS WITH RACIAL INJUSTICE

Boston Lawmakers Vote To Ban Use Of Facial Recognition Technology By The City

JUNE 24, 2020 · 7:05 PM ET

FROM ◼ wbur

By Ally Jarmanning

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4 APRIL 2024 / BAY AREA SPORTS / JOE KUKURA

Giants Set to Use Facial Recognition on Fans, Privacy Advocates Say It's a Slap in the Face

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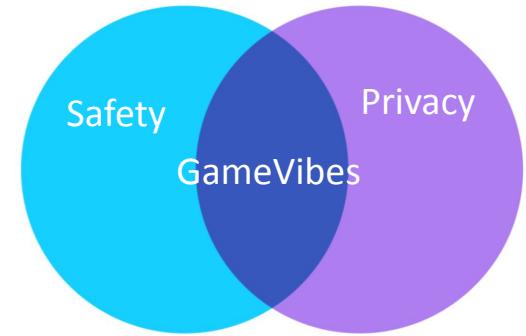
Crowd Monitoring WITHOUT the Regulatory Risk

EU alone:

- 27 countries
- ~300-500 stadiums per major country (Germany, France, UK, Italy, Spain)

US privacy-strict cities:

- 20+ cities with facial recognition bans
- Average 50-100 venues per city (including high schools, colleges, pro)

Safety   Privacy
GameVibes

Thank You!

Any Questions?

(Don't worry you are not being recorded)